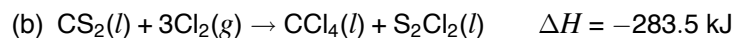


SUMMARY PROBLEM

$$(a) \text{ yes; } \Delta H = \frac{-9.310 \text{ kJ}}{2.500 \text{ g CS}_2} \times \frac{76.13 \text{ g CS}_2}{1 \text{ mol}} = -283.5 \text{ kJ}$$



$$(c) -(-283.5 \text{ kJ})(\frac{1}{3}) = 94.50 \text{ kJ}$$

$$(d) \text{ mol Cl}_2 = \frac{-5.00 \text{ kJ} \times 3 \text{ mol Cl}_2}{-283.5 \text{ kJ}} = 0.0529; V = \frac{0.0529 \text{ mol} \times 0.0821 \text{ L} \cdot \text{atm/mol} \cdot \text{K} \times 300 \text{ K}}{(812/760) \text{ atm}} = 1.22 \text{ L}$$

$$(e) -283.5 = -135.4 + \Delta H_f^\circ \text{ S}_2\text{Cl}_2 - 89.9; \quad \Delta H_f^\circ \text{ S}_2\text{Cl}_2 = -58.2 \text{ kJ/mol}$$

$$(f) q_{\text{reaction}} = 0.01000 \text{ g CS}_2 \times \frac{-9.310 \text{ kJ}}{2.5000 \text{ g}} = -0.03724 \text{ kJ} = -37.24 \text{ J}$$

$$q_{\text{H}_2\text{O}} = -q_{\text{reaction}} = -(-37.24 \text{ J}) = 37.24 \text{ J}$$

$$37.24 \text{ J} = 6.450 \text{ g} \times 4.18 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}} \times (t_f - 22.0)^\circ\text{C} \quad t_f = 23.4^\circ\text{C}$$

$$(g) \text{ mol Cl}_2 = \frac{5.00 \text{ L} \times 2.78 \text{ atm}}{0.0821 \text{ L} \cdot \text{atm/mol} \cdot \text{K} \times 300 \text{ K}} = 0.564; \quad 0.564 \text{ mol Cl}_2 \times \frac{(-283.5 \text{ kJ})}{3 \text{ mol Cl}_2} = -53.3 \text{ kJ}$$

$$\text{mol CS}_2 = 50.0 \text{ mL} \times (1.263 \text{ g/mL}) \times (1 \text{ mol}/76.13 \text{ g}) = 0.0830$$

$$0.830 \text{ mol CS}_2 \times (-283.5 \text{ kJ/mol}) = -235.3 \text{ kJ}$$

Cl₂ is limiting; 53.3 kJ evolved

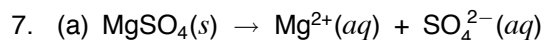
PROBLEMS

$$1. \quad \Delta t = \frac{4.78 \text{ J}}{(5.88 \text{ g})(0.523 \text{ J/g} \cdot ^\circ\text{C})} = 1.55^\circ\text{C}$$

$$3. \quad \text{specific heat} = \frac{62.5 \text{ J}}{(5.00 \text{ g})(50.8 - 23.00)^\circ\text{C}} = 0.450 \text{ J/g} \cdot ^\circ\text{C}$$

$$5. \quad 375^\circ\text{F} = 191^\circ\text{C}$$

$$q = 0.902 \text{ J/g} \cdot ^\circ\text{C} \times 473 \text{ g} \times (191 - 23)^\circ\text{C} = 7.16 \times 10^4 \text{ J}$$



(b) yes

$$(c) q_{\text{H}_2\text{O}} = 1/51 \text{ kJ}$$

$$(d) \Delta t = \frac{1.51 \times 10^3 \text{ J}}{(4.18 \text{ J/g} \cdot ^\circ\text{C})(15.0 \text{ g})} = 24.1^\circ\text{C}; \quad t_f = 49^\circ\text{C}$$

$$(e) 77^\circ\text{F}; \quad 120^\circ\text{F}$$

$$9. \quad 225 \times 4.18 \times (t_f - 25) = -[85 \times 4.18 \times (t_f - 25)]; \quad t_f = 42.5^\circ\text{C}$$

$$11. (a) \quad q_{\text{H}_2\text{O}} = (35.0 \text{ g} + 35.0 \text{ g}) \times 4.18 \text{ J/g} \cdot ^\circ\text{C} \times (31.29^\circ\text{C} - 22.0^\circ\text{C}) = 2.72 \times 10^3 \text{ J}$$

$$q_{\text{rxn}} = -q_{\text{H}_2\text{O}} = -2.72 \times 10^3 \text{ J}$$

$$(b) \quad n_{\text{NaOH}} = 0.0350 \text{ L} \times 1.43 \text{ mol/L} = 0.0501; \quad q_{\text{neut}} = 1 \text{ mol NaOH} \times \frac{(-2.72 \times 10^3 \text{ J})}{0.0501 \text{ mol}} = -5.43 \times 10^4 \text{ J}$$

$$13. (a) \quad q_{\text{cal}} = (2.115 \times 10^4 \text{ J/}^\circ\text{C})(27.71^\circ\text{C} - 23.49^\circ\text{C}) = 8.93 \times 10^4 \text{ J} = 89.3 \text{ kJ}$$

$$(b) \quad q_{\text{rxn}} = -89.3 \text{ kJ}$$

$$(c) \quad q = \frac{-89.3 \text{ kJ}}{4.50 \text{ g fructose}} \times \frac{180.2 \text{ g fructose}}{1 \text{ mol}} = -3.58 \times 10^3 \text{ kJ}$$

$$15. \quad C_{\text{cal}} = \frac{330 \text{ kJ}}{43.3^\circ\text{C}} = 7.62 \text{ kJ/}^\circ\text{C}$$

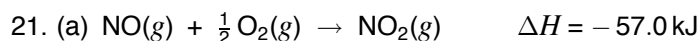
$$17. \quad q_{\text{rxn}} = 0.0100 \text{ g} \times (-24.06 \text{ kJ}/0.500 \text{ g}) = -0.481 \text{ kJ} = -481 \text{ J}$$

$$q_{\text{cal}} = -q_{\text{rxn}} = +481 \text{ J}; \quad 481 \text{ J} = (5175 \text{ J/}^\circ\text{C})(t_f - 23.6^\circ\text{C}); \quad t_f = 23.7^\circ\text{C}$$

$$19. \quad C_{\text{cal}} = 9.37 \text{ kJ}/2.48^\circ\text{C} = 3.78 \text{ kJ/}^\circ\text{C}$$

$$q_{\text{rxn}} = -q_{\text{cal}} = -[3.78 \text{ kJ/}^\circ\text{C} \times (28.91 - 23.11)^\circ\text{C}] = -21.9 \text{ kJ}$$

$$\frac{-21.9 \text{ kJ}}{1.00 \text{ g}} \times \frac{138.1 \text{ g}}{1 \text{ mol}} = -3.02 \times 10^3 \text{ kJ/mol}$$



(b) exothermic

(c) products 57.0 kJ below reactants

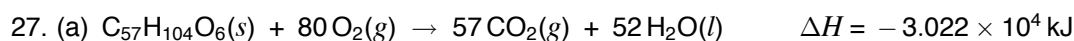
$$(d) \quad 5.00 \text{ g NO} \times \frac{-57.0 \text{ kJ}}{30.01 \text{ g NO}} = -9.50 \text{ kJ}$$

$$(e) \quad 10.0 \text{ kJ} \times \frac{30.01 \text{ g NO}}{57.0 \text{ kJ}} = 5.26 \text{ g NO}$$

$$23. (a) -637 \text{ kJ}/4 = -159 \text{ kJ} \quad (b) 10.00 \text{ g NH}_3 \times \frac{637 \text{ kJ}}{17.03 \text{ g NH}_3} = +374 \text{ kJ}$$



$$(b) n_{\text{O}_2} = \frac{(1.00 \text{ atm})(10.00 \text{ L})}{(0.0821 \text{ L} \cdot \text{atm}/\text{mol} \cdot \text{K})(298 \text{ K})} = 0.409 \text{ mol}; \quad \Delta H = 0.409 \text{ mol O}_2 \times \frac{-1220 \text{ kJ}}{1.50 \text{ mol O}_2} = -332 \text{ kJ}$$



$$(b) 5.000 \text{ lb} \times \frac{453.6 \text{ g}}{1 \text{ lb}} \times \frac{1 \text{ mol}}{885.4 \text{ g}} \times \frac{3.022 \times 10^4 \text{ kJ}}{1 \text{ mol}} = 7.741 \times 10^4 \text{ kJ}$$

$$(c) 7.741 \times 10^4 \text{ kJ} \times \frac{1 \text{ kcal}}{4.184 \text{ kJ}} = 1.850 \times 10^4 \text{ kcal}$$

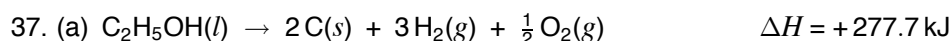
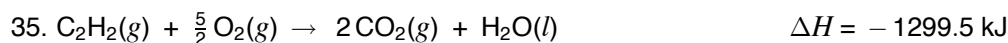
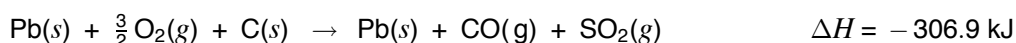
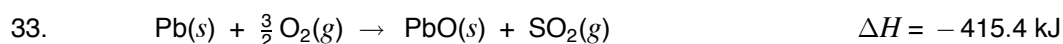
$$29. 100.0 \text{ g C}_6\text{H}_6 \times \frac{1 \text{ mol}}{78.11 \text{ g}} \times \frac{30.8 \text{ kJ}}{1 \text{ mol}} = 39.4 \text{ kJ}; \quad 20.0 \text{ g H}_2\text{O} \times \frac{1 \text{ mol}}{18.02 \text{ g}} \times \frac{40.7 \text{ kJ}}{1 \text{ mol}} = 45.2 \text{ kJ}$$

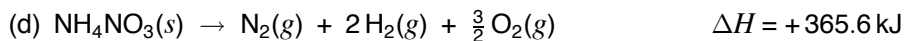
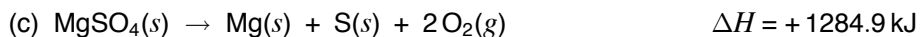
boiling water absorbs more heat

$$31. (a) \Delta H = 10.0 \text{ g Br}_2 \times 0.474 \text{ J/g} \cdot ^\circ\text{C} \times (59.0 - 22.5)^\circ\text{C} = 173 \text{ J} = 0.173 \text{ kJ}$$

$$(b) \Delta H = 10.0 \text{ g Br}_2 \times \frac{1 \text{ mol}}{159.8 \text{ g}} \times \frac{29.6 \text{ kJ}}{1 \text{ mol}} = 1.85 \text{ kJ}$$

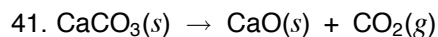
$$(c) 1.85 \text{ kJ} + 0.173 \text{ kJ} = 2.02 \text{ kJ}$$





$$39. (a) \Delta H_f^\circ \text{Al}_2\text{O}_3 = -3351.4 \text{ kJ}/2 = -1675.7 \text{ kJ}$$

$$(b) 12.50 \text{ g Al}_2\text{O}_3 \times \frac{1 \text{ mol Al}_2\text{O}_3}{101.96 \text{ g Al}_2\text{O}_3} \times \frac{-1675.7 \text{ kJ}}{1 \text{ mol Al}_2\text{O}_3} = -205.4 \text{ kJ}$$



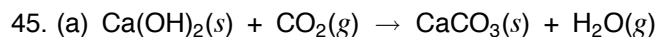
$$\Delta H^\circ = -635.1 \text{ kJ} - 393.5 \text{ kJ} + 1206.9 \text{ kJ} = +178.3 \text{ kJ}$$

$$1.000 \text{ g CaCO}_3 \times \frac{1 \text{ mol CaCO}_3}{100.1 \text{ g CaCO}_3} \times \frac{+178.3 \text{ kJ}}{1 \text{ mol CaCO}_3} = +1.781 \text{ kJ}$$

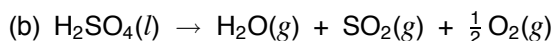
$$43. (a) \Delta H^\circ = -466.8 \text{ kJ} - 92.2 \text{ kJ} - 571.6 \text{ kJ} + 924.5 \text{ kJ} + 265.0 \text{ kJ} = +58.9 \text{ kJ}$$

$$(b) \Delta H^\circ = -110.5 \text{ kJ} + 219.0 \text{ kJ} = +108.5 \text{ kJ}$$

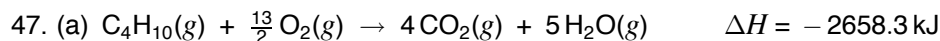
$$(c) \Delta H^\circ = -220.8 \text{ kJ} - 296.8 \text{ kJ} - 571.6 \text{ kJ} + 909.3 \text{ kJ} = -179.9 \text{ kJ}$$



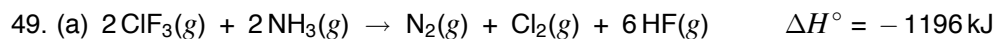
$$\Delta H^\circ = -1206.9 \text{ kJ} - 241.8 \text{ kJ} + 986.1 \text{ kJ} + 393.5 \text{ kJ} = -69.1 \text{ kJ}$$



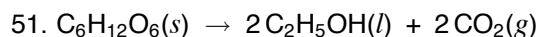
$$\Delta H^\circ = -241.8 \text{ kJ} - 296.8 \text{ kJ} + 814.0 \text{ kJ} = +275.4 \text{ kJ}$$



$$(b) -2658.3 \text{ kJ} = 4(-393.5 \text{ kJ}) + 5(-241.8 \text{ kJ}) - \Delta H_f^\circ \text{C}_4\text{H}_{10}(g); \quad \Delta H_f^\circ \text{C}_4\text{H}_{10}(g) = -124.7 \text{ kJ/mol}$$



$$(b) -1196 \text{ kJ} = 6(-271.1 \text{ kJ}) + 2(46.1 \text{ kJ}) - 2\Delta H_f^\circ \text{ClF}_3(g); \quad \Delta H_f^\circ \text{ClF}_3(g) = -169 \text{ kJ/mol}$$



$$\Delta H^\circ = -555.4 \text{ kJ} - 787.0 \text{ kJ} + 1275.2 \text{ kJ} = -67.2 \text{ kJ}$$

$$\text{moles C}_2\text{H}_5\text{OH} = 750.0 \text{ mL} \times 0.120 \times \frac{0.789 \text{ g}}{1 \text{ mL}} \times \frac{1 \text{ mol}}{46.07 \text{ g}} = 1.54 \text{ mol}$$

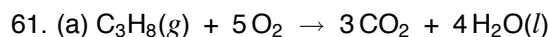
$$\Delta H = 1.54 \text{ mol} \times \frac{-67.2 \text{ kJ}}{2 \text{ mol}} = -51.8 \text{ kJ}$$

$$53. 3.27 \text{ L} \cdot \text{atm} \times \frac{0.1013 \text{ kJ}}{1 \text{ L} \cdot \text{atm}} = 0.331 \text{ kJ}$$

$$55. (a) \Delta E = +18 \text{ J} + 13 \text{ J} = +31 \text{ J} \quad (b) +61 \text{ kJ} = q + 72 \text{ J}; \quad q = -11 \text{ J}$$

$$57. \Delta E = q + w = -1185 \text{ J} + 623 \text{ J} = -562 \text{ J}$$

$$59. \Delta H = \Delta E - RT; \quad \Delta H - \Delta E = -8.31 \text{ J/K} \times 298 \text{ K} = -2.48 \text{ kJ}$$



$$(b) \Delta H = 3(-393.5 \text{ kJ}) + 4(-285.8 \text{ kJ}) + 103.8 \text{ kJ} = -2219.9 \text{ kJ}$$

$$\Delta H = \Delta E - 3(0.00831)(298)\text{kJ}; \quad \Delta E = -2219.9 \text{ kJ} - 3(0.00831)(298)\text{kJ}; \quad \Delta E = -2212.5 \text{ kJ}$$

$$63. q_{\text{H}_2\text{O}} = 1.000 \text{ qt} \times \frac{1000 \text{ mL}}{1.057 \text{ qt}} \times \frac{1.000 \text{ g}}{1 \text{ mL}} \times 4.18 \text{ J/g} \cdot ^\circ\text{C} \times (100 - 20)^\circ\text{C} = 3.16 \times 10^5 \text{ J} = 316 \text{ kJ}$$

$$\Delta H = -393.5 + 2(-241.8) - (-74.8) = -802.3 \text{ kJ}$$

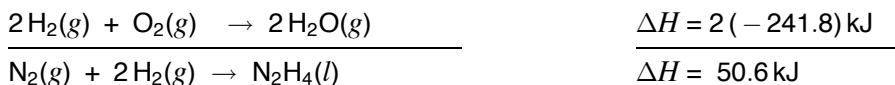
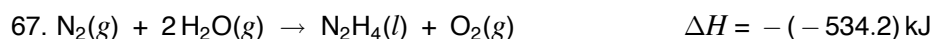
$$q_{\text{reaction}} = -q_{\text{H}_2\text{O}} = -316 \text{ kJ}; \quad \text{mol CH}_4 = -316 \text{ kJ} \times \frac{1 \text{ mol CH}_4}{-802.3 \text{ kJ}} = 0.394$$

$$V = \frac{(0.394 \text{ mol})(0.0821 \text{ L} \cdot \text{atm/mol} \cdot \text{K})(293 \text{ K})}{1.00 \text{ atm}} = 9.47 \text{ L}$$

$$65. (a) 1.000 \text{ therm} = \frac{1.00 \times 10^5 \text{ BTU}}{1 \text{ therm}} \times \frac{1 \text{ J}}{9.48 \times 10^{-4} \text{ BTU}} = 1.05 \times 10^8 \text{ J}$$

$$(b) \Delta H = 3(-393.5) + 4(-241.8) - (-103.8) = -2043.9 \text{ kJ}$$

$$\frac{2043.9 \text{ kJ}}{1 \text{ mol C}_3\text{H}_8} \times \frac{1 \times 10^3 \text{ J}}{1 \text{ kJ}} \times \frac{1 \text{ therm}}{1.05 \times 10^8 \text{ J}} = 0.0195 \text{ therm}$$



$$69. 1.0 \text{ lb fat} \times \frac{454 \text{ g}}{1 \text{ lb}} \times \frac{32 \text{ kJ}}{1 \text{ g}} \times \frac{1 \text{ kcal}}{4.18 \text{ kJ}} \times \frac{0.500 \text{ h}}{225 \text{ kcal}} = 7.7 \text{ h}$$

$$71. \text{mass of brass} = (2.200 \text{ cm})^3 \times (8.25 \text{ g/cm}^3) = 87.8 \text{ g}$$

$$q_{\text{brass}} = -q_{\text{H}_2\text{O}}$$

$$87.8 \text{ g} \times 0.362 \text{ J/g} \cdot ^\circ\text{C} \times (t_f - 95.0)^\circ\text{C} = -[20.0 \text{ g} \times 4.18 \text{ J/g} \cdot ^\circ\text{C} \times (t_f - 22.0)^\circ\text{C}]; \quad t_f = 42.1^\circ\text{C}$$

$$73. E_{\text{microwave}} = \frac{(6.626 \times 10^{-34} \text{ J} \cdot \text{s}) \times (2.998 \times 10^8 \text{ m/s})}{0.125 \text{ m}} = 1.59 \times 10^{-24} \text{ J/photon}$$

$$q_{\text{H}_2\text{O}} = 350.0 \text{ g} \times 4.18 \text{ J/g} \cdot ^\circ\text{C} \times (99.0 - 23.0)^\circ\text{C} = 1.11 \times 10^5 \text{ J}$$

$$1.11 \times 10^5 \text{ J} \times \frac{1 \text{ photon}}{1.59 \times 10^{-24} \text{ J}} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ photons}} = 1.16 \times 10^5 \text{ mol}$$

$$75 \text{ (a) } q = (100.0 \times 10^3 \text{ g}) \times (0.82 \text{ J/g} \cdot ^\circ\text{C}) \times (12^\circ\text{C}) = 9.8 \times 10^5 \text{ J}$$

$$\text{(b) } \frac{9.8 \times 10^5 \text{ J}}{2 \text{ m}^2} \times \frac{1 \text{ m}^2}{170 \text{ watt}} \times \frac{1 \text{ watt}}{1 \text{ J/s}} \times \frac{1 \text{ min}}{60 \text{ s}} = 48 \text{ min}$$

77. Volume increases; work is done by the system.

79. (a) T (b) T (c) T (d) F (e) F

81. (a) T (b) T (c) F (d) T

83. (a) T (b) T (c) F (d) F

$$84. E_{\text{microwave}} = \frac{(6.626 \times 10^{-34} \text{ J} \cdot \text{s}) \times (2.998 \times 10^8 \text{ m/s})}{0.125 \text{ m}} = 1.59 \times 10^{-24} \text{ J/photon}$$

$$q_{\text{H}_2\text{O}} = 100.0 \text{ g} \times 4.18 \text{ J/g} \cdot ^\circ\text{C} \times (80.0)^\circ\text{C} = 3.34 \times 10^4 \text{ J}$$

$$3.34 \times 10^4 \text{ J} \times \frac{1 \text{ photon}}{1.59 \times 10^{-24} \text{ J}} = 2.1 \times 10^{28} \text{ photon}$$

$$85. \text{(a) } (12.5 \text{ g} \times 20.0^\circ\text{C} \times 6 \times 0.902 \text{ J/g} \cdot ^\circ\text{C}) + \left(\frac{72.0}{16.0} \text{ lb} \times \frac{453.6 \text{ g}}{1 \text{ lb}} \times 4.10 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}} \times 20.0^\circ\text{C} \right) = 1.68 \times 10^5 \text{ J}$$

$$\text{(b) } 168 \text{ kJ} \times \frac{18.02 \text{ g}}{6.00 \text{ kJ}} = 505 \text{ g}$$

86. room temperature $\approx 25^\circ\text{C}$

$$\text{Assume } 100 \text{ g water: } q = 100 \text{ g} \times 25^\circ\text{C} \times 4.18 \text{ J/g} \cdot ^\circ\text{C} = 10,400 \text{ J}$$

$$\text{mass of ice required} = 10.4 \text{ kJ} \times \frac{1 \text{ mol}}{6.00 \text{ kJ}} \times \frac{18.02 \text{ g}}{1 \text{ mol}} = 31.2 \text{ g}$$

$$V_{\text{H}_2\text{O}} = \frac{100 \text{ g}}{1.00 \text{ g/cm}^3} = 100 \text{ cm}^3; \quad V_{\text{ice}} = \frac{31.2 \text{ g}}{0.90 \text{ g/cm}^3} = 35 \text{ cm}^3$$

$$\text{fraction} = 35/(100 + 35) = 0.26$$

87. (a) $\Delta H = \Delta H_f^\circ \text{Al}_2\text{O}_3(s) - \Delta H_f^\circ \text{Fe}_2\text{O}_3(s) = -851.5 \text{ kJ}$

(b) $851500 \text{ J} = [(0.77 \text{ J/g} \cdot ^\circ\text{C})(101.96 \text{ g}) + (0.45 \text{ J/g} \cdot ^\circ\text{C})(111.7 \text{ g})] \Delta t; \quad \Delta t = 6600^\circ\text{C}$

(c) Yes

88. Let x = mass of sucrose

$$q = (22.51 \text{ kJ/}^\circ\text{C})(1.67^\circ\text{C})$$

$$(22.51 \text{ kJ/}^\circ\text{C})(1.67^\circ\text{C}) = \frac{5640 \text{ kJ}}{342.3 \text{ g}}(x); \quad x = 2.28 \text{ g}; 76.0\%$$

89. $E_{\text{microwave}} = \frac{(6.626 \times 10^{-34} \text{ J} \cdot \text{s}) \times (2.998 \times 10^8 \text{ m/s})}{0.135 \text{ m}} = 1.47 \times 10^{-24} \text{ J/photon}$

$$q = 1.47 \times 10^{-24} \frac{\text{J}}{\text{photon}} \times \frac{6.022 \times 10^{23} \text{ photons}}{1 \text{ mol}} \times \frac{925 \text{ mol}}{\text{s}} \times 1.55 \text{ s} = 1270 \text{ J}$$

$$1270 \text{ J} = \text{mass} \times (0.45 \text{ J/g} \cdot ^\circ\text{C}) \times (400 - 25)^\circ\text{C}; \quad \text{mass} = 7.50 \text{ g}$$